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as Reserve Assets**

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**ECONOMICS DEPARTMENT**

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## U.S. Dollar and Deutschmark as Reserve Assets

by

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### Abstract

The application of mean-variance portfolio models to the reserve management of central banks reveals that authorities do not optimally diversify their foreign-exchange portfolio. The paper suggests that the underdiversification into DM assets is largely due to the resistance of the Bundesbank to promote the DM's international role motivated by the fear to loose control over monetary policy. The paper then presents a model on reserve diversification based on the view that diversification away from dollar holdings was mainly caused by the removal of the convertibility constraint on official dollar balances. The analysis suggests that this constraint was reestablished by the evolution of the Deutschmark as a second main reserve currency - attributing the dominant role of the dollar to the size of the U.S. economy and its capital market and the increasing role of the Deutschmark to the Bundesbank's reputation to provide a predictable and low-inflationary currency - and that reserve diversification can therefore be regarded as a stabilizing element in the international monetary system.

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## Introduction

The composition of foreign-exchange reserves of central banks has undergone substantial changes over the last few years. Since the end of the Bretton Woods era during which the U.S. dollar accounted for 80-90 percent of official currency holdings a considerable degree of diversification out of dollar holdings can be observed for two periods. One was the diversification carried out between 1978 and 1980. This period was characterized by a decline in absolute total dollar holdings and a depreciation of the dollar exchange rate. The other was the large-scale diversification between the early 1980s and 1985. This diversification coincided with the sharp appreciation of the dollar exchange rate. Especially in 1978 and 1979, the counterpart of reserve switches out of the dollar was a substantial increase of Deutschmark holdings. The complementary development between DM and dollar holdings can also be observed for the 1980s although it appears to have been less pronounced.<sup>1</sup>

The major part of existing studies on the composition of foreign-exchange holdings of central banks builds on the mean-variance portfolio approach stressing the influence of risk and return associated with reserve holdings denominated in different currencies. An earlier study used an alternative strategy. Heller and Knight (1978) build on the inventory approach stressing that reserves are generally used to finance deficits and accumulated from surpluses in international transactions. The use of reserves for deficit financing reflects the basic role of reserves, i.e. to defend the exchange rate of a currency through intervention on foreign-exchange markets if the external payments position of the issuing country is in deficit. Very recently, Dooley, Lizondo and Mathieson (1989) attempted to link the two approaches by including

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1. The described development reflects diversification of aggregate reserve portfolios 'net' of distributional effects which include changes in the currency composition of reserve holdings of US authorities and the below-average growth of reserve holdings of Germany assuming that the entire foreign-exchange portfolio of these two countries are denominated in dollars [see Horii (1986) and Mayer (1990)].

the use of a specific reserve currency in international transactions in a mean-variance portfolio model. However, the basic structure of their empirical analysis is identical to the one used by Heller and Knight (1978).

The two approaches come to different conclusions. The inventory approach suggests to highly concentrate official foreign-exchange holdings in U.S. dollars due to the presence of economies of scale involved in asset-exchange costs if all indirect international transactions are done in one single ('vehicle') currency. With this approach, a certain degree of diversification away from dollar holdings may be explained by a decline in the use of the US dollar in transactions among the major countries of the world economy in the last few years due to a reduction of transactions costs on dollar versus major non-dollar currencies.

The studies applying international portfolio selection theory to the management of foreign-exchange holdings of central banks [Kouri and de Macedo (1978), de Macedo (1982), Ben-Bassat (1984), Horii (1986)] suggest that - in particular for industrial countries - the dollar should be playing a substantially smaller role than is in fact the case whereas the Deutschmark is under-represented in the actual portfolio mix.

One major reason for the gap between optimal and actual portfolio compositions may be that central banks manage only parts of their foreign-exchange holdings in accordance with portfolio selection models. Other possible criteria may include the mutual currency agreements in the European Monetary System (and previously in the Snake) to limit holdings of member currencies to working balances and considerations of international monetary stability.

Since central banks seem to have committed themselves to stable exchange rates even after the adoption of widespread floating reserve diversification would only be unconstrained under the assumption that central banks' transactions on exchange markets have no price effects, i.e. are not an independent source of exchange-rate instability. This assumption holds, however, only if the volume converted from one currency to another is relatively



small and if a number of currencies offer a sufficiently wide range of investment possibilities and a broad asset market.

This means that reserve diversification is subject to two constraints. Markets of only few currencies have a degree of financial intermediation sufficiently high in order to avoid being disturbed by a given volume of transactions. This was reflected in the attitude of the Bundesbank to actively discourage use of the DM as a reserve asset for much of the period since 1973. In addition, the degree of reserve diversification of individual central banks seems to be partly a function of the level of reserves meaning that the lower the proportion of reserves held by a country for transactions purposes, i.e. the larger its 'idle' balances, the larger is the impact on exchange rates of its potential currency conversions. Accordingly, the gap between optimal and actual reserve portfolios present for a number of industrial countries with large foreign-exchange holdings may be caused by considerations of international monetary stability. The author [Mayer (1989)] has shown elsewhere that industrial countries in fact tend to change their reserve composition only in periods when this policy is in accordance with exchange rate stabilization.

The second major cause for the gap between actual and optimal reserve portfolios may be seen in the institutional problems of any international monetary system, i.e. questions associated with the adjustment problem and the confidence problem. This will be the focus of this paper.

The scope of the following analysis is to trace the reasons for the gap between actual reserve portfolios of central banks and the portfolios calculated by the various studies on this issue by studying the impact of the presence of a number of reserve currencies on the conduct of monetary policy by reserve-currency countries. The structure of the paper is as follows: Section 2 focuses on the reasons that make international monetary system tend to evolve asymmetrically and that make one specific currency attain a special role in the system. Section 3 emphasizes the importance of the presence of a convertibility constraint on a reserve currency and models the workings of this constraint in an international

monetary system with more than one main reserve currency. The conclusions are drawn in Section 4.

## 2. Adjustment and Confidence in an International Monetary System

The questions of adjustment and confidence are at the heart of any international monetary system as they determine the system's degree of symmetry and thus the degree of independence of each individual member country's monetary policy.

Adjustment refers to "... the process by which deficits and surpluses [in the payments positions of individual countries] are eliminated" [Machlup and Malkiel (1964, p. 25)]. In the Bretton Woods system, the United States were able to finance their payments deficits through the increase of dollar-denominated liabilities due to the dollar's role as a reserve currency. The authorities of other countries had to acquire these liabilities in order to avoid an appreciation of their currencies, thus depriving themselves of any control over domestic monetary policy. Deficits by non-reserve-currency countries, by contrast, had to be balanced by a transfer of assets. This means that the burden of adjustment was asymmetrically allocated to the countries other than the United States. The breakdown of the Bretton Woods system did not substantially change this principle although - in addition to the United States - the new reserve-currency countries have been enabled to settle payments deficits by issuing liabilities denominated in their own currencies.

Confidence in reserve media refers to "... the need for avoiding sudden switches between different reserve media" [Machlup and Malkiel (1964, p. 24)]. These switches are associated with depreciation risk connected with currency holdings. Holders of foreign-exchange reserves are not exposed to depreciation risk in only two cases. One is the assured convertibility of the dominant reserve currency into a commodity at a fixed price. In history, this commodity has mainly been gold. The other case in which holders of foreign-exchange reserves are not exposed to depreciation risk is when no convertibility constraint of the reserve currency into a



commodity exists but exchange-rate changes in the system - be it a fixed exchange-rate system or managed floating - can typically be expected as depreciations of non-reserve currencies relative to the reserve currency. This means that the reserve currency of the system would be that currency which is least likely to depreciate or - assuming purchasing power parity to hold - that has the lowest average inflation rate of the system.

The issues of adjustment and confidence are closely related to the  $(n-1)$  problem. In a world economy with  $n$  currencies, there are only  $(n-1)$  independent exchange rates. Equally, in a world economy with  $n$  countries, only  $(n-1)$  countries need achieve balance-of-payments equilibrium. That is, one country is spared a balance-of-payments constraint, or in other words, it exerts benign neglect with respect to its balance of payments and hence to its exchange rate. On the other hand, the currency of the  $n$ -th country takes the role of the nominal anchor of the system. Accordingly, the  $n$ -th country uses the degree of freedom to pursue an independent - and ideally low-inflationary - monetary policy which sets the path of inflation throughout the system.

Since historical examples show that monetary regimes have tended to asymmetry, i.e. that one currency has played a special role in the international monetary system (pound Sterling in the gold standard, the US dollar in the Bretton Woods system, and the Deutschmark in the EMS), the question arises as to the sources of asymmetry in monetary regimes. Three phenomena regarding the generation of asymmetry can be distinguished: diverging size of economies, diverging stability of currencies, and the form in which exchange rates are managed and reserves are held.

## 2.1 Asymmetry Caused by Diverging Size of Countries

The first explanation regarding differences in size is that the maintenance of world price stability requires dividing adjustment to country-specific disturbances in inverse proportion to the size of countries involved as shown by Mundell (1968, Ch. 13).

The second explanation is based on the evolution of international financial intermediation. The world's principal international financial intermediary has a considerable influence on conditions in money and credit markets worldwide. For one, a given rise in interest rates on the dominant capital market encourages international investors to transfer more capital into that market than the same rise in interest rates would lead them to transfer into a smaller capital market. Countries with evolved international financial intermediation can therefore balance current-account deficits relatively easily by capital flows. This is because breadth and depth of capital markets increase with an evolved system of international financial intermediation since investment in broad and deep markets is less risky than in thin ones. Moreover, resiliency of a capital market grows with its evolving role in international financial intermediation. This means that with a resilient capital market a country incurs lower costs associated with the role of a reserve center. The perceived loss of control over monetary policy, i.e. a reserve-currency country's fear of not always being able to sterilize the effects on domestic monetary aggregates of variations in the external demand for its currency has tended to make 'new' reserve centers reluctant to accept this special role for their currencies.

The underdiversification into DM assets may be explained within this context. The supply of short-term Treasury bills - the form of investment central banks tend to prefer - is considerably higher on the US capital market than on the German. This appears to have been part of the Bundesbank's strategy to deliberately discourage use of the DM as a reserve asset. It was argued that a continuing reserve diversification into DM assets would either lead to an excessive appreciation of the DM or, if the Bundesbank executed non-sterilized interventions, would undermine monetary policy [Deutsche Bundesbank (1979)]. However, with the experience of substantial current-account deficits between 1979-1981 German authorities found it convenient to borrow abroad in their own currency and increased the supply of DM-denominated assets - a measure also taken to lessen the pressure on foreign exchange markets. Nonetheless, the Bundesbank kept on worrying about extending the DM's international role in the face of the limited capacity of



the German money and capital markets [Rieke (1982) and Deutsche Bundesbank (1984)].

A third explanation comes from diverging extents to which currencies are used in international transactions. Global welfare increases if all international transactions are made in the same currency because the use of a specific currency as a vehicle for international transactions lowers transactions costs of international exchange. This feature is accentuated by the fact that once a currency has obtained a comparative advantage in reducing transactions costs, a self-perpetuating process tends to reinforce the vehicle role of that currency [Jones (1976) and Chrystal (1984)].

## 2.2 Asymmetry Caused by Diverging Stability of Currencies

Asymmetry in monetary regimes may also occur when one currency is relatively more stable than other currencies. Starting from a situation in which the inflation rate in one country is higher than in another and the first country wants to disinflate, the central bank of the disinflating country may want to raise its credibility when it announces to adopt an austerity program. The credibility literature following Kydland and Prescott (1977) and Barro and Gordon (1983a,b) has shown that the costs of disinflation are smaller when domestic residents believe that the program announced will actually be realized. The inflation-prone country can import the necessary credibility by linking its currency to a currency whose issuer has a higher reputation - be it by actually pegging the exchange rate or by a close management of the exchange rate with respect to the more stable currency. The disinflating country imports reputation by giving up independence of its monetary policy - the system becomes asymmetric.

The core of this argument is that by pegging to a more stable currency the central bank manages to convince the other economic agents that it will carry through a disinflation. Whether these other agents are wage setters or holders of non-indexed government bonds, the crucial aspect is the inflationary impact of shifts in expectations caused by a change in the policy regime. The argument

relies on the credibility of the central bank's commitment to the exchange rate target. In a disinflationary strategy, exchange-rate pegging may be preferred to money growth targeting because of credibility problems of central banks, and because a reduction in the rate of money growth raises real interest rates - and hence, induces a recession - if goods prices are sticky.<sup>2</sup>

The adoption of an exchange-rate peg provides additional discipline to monetary authorities in inflation-prone countries because it forces the policymaker to accept a higher cost to expansionary policy through real appreciation. Assuming that realignments devalue the currency of the inflation-prone central bank by at most enough to restore purchasing-power parity (PPP), any monetary expansion causing inflation leads to a real appreciation - until the next realignment - which causes a loss in competitiveness and hence tends to reduce output. Inflation is lower in such a monetary regime than in a regime with purely flexible exchange rates which maintains PPP throughout, disregarding the domestic inflation rate. On the other hand, if the currency to which the domestic currency is pegged is more inflationary, inflation will be imported. Hence, monetary regimes whose objective is to disinflate tend to become asymmetrical by allocating the nominal anchor position to the least inflationary currency.

Pegging to a more stable currency has an important bearing on the choice of 'who intervenes'. If a currency is to serve as nominal anchor for the monetary system, its issuer must not intervene to stabilize cross rates if the cross rates are under pressure due to excessive monetary expansion by other members of the system. Non-sterilized intervention of the reserve-currency country would mean that it accepts the monetary expansion of its

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2. Since a reduction in the rate of money growth decreases inflationary expectations and thus raises money demand, nominal interest rates need to increase to equilibrate the money market given the real stock of money and sticky prices. Due to the decrease in inflationary expectations the increase in nominal interest rates is reflected in an increase in real interest rates.



partner country, thereby compromising its role as anchor of the system by a loss of reputation.

The question of 'who intervenes' is very important from another angle as well. The ability of the United States to exploit its role as a reserve-currency country by raising seigniorage gains depends primarily on the stock of dollars in the portfolio of reserve holders. However, suppose that these holders are dissatisfied with the behavior of the US authorities, perhaps because of real value losses, and begin to shift into Deutschmark for example. Then, the Bundesbank must take up the dollars that others want to shed if it wants to prevent the dollar from depreciating, thereby causing a depreciation of the Bundesbank's currency reserves. Hence, a flow of dollar reserves from one holder to another does not reduce the influence of US policies on the world economy. In general, even if the reserve-currency country does not issue the most stable currency any longer whether or not it manages to exploit its special role depends on its role in exchange-rate management.

### 2.3 Asymmetry caused by the Form of Exchange-Rate Management and Reserve Holding

The third source of asymmetry involves two issues. The use of a currency for intervention in foreign-exchange markets tends to affect the domestic monetary aggregates of the country issuing the intervention currency. However, these effects can be sterilized either deliberately by compensating policy measures of domestic monetary authorities or automatically by the form in which intervention is financed and reserves are held by foreign monetary authorities. A reserve-currency country may therefore be able to completely isolate its domestic monetary aggregates from influences of its currency's use in exchange-rate management and put the entire burden of adjustment on the other countries.

A result similar to Mundell's 'relative size criterion' is obtained by Swoboda (1978). He (p. 631) shows that - in the case where money multipliers are equal in the two countries - "open



market purchases of securities increase the domestic money supply in proportion to the country's relative size." This is because an expansionary open-market operation in one country does not only raise its domestic money supply but also world money supply. However, the effect on world money supply is limited to the expansionary country's relative size, i.e. the given change in the world money stock is distributed among the two countries in the fixed proportions of their relative economic sizes. The expansionary country creates an excess supply of money and experiences a payments deficit and thus a reserve loss. This reserve loss raises the money supply in the non-expansionary country and decreases it in the expansionary country. The reserve loss approaches an amount equal to the initial money expansion as the relative size of the expansionary country becomes negligibly small.

Swoboda (1978) also shows that asymmetry can be introduced in a monetary regime by the way in which currency reserves are held. This argument is based on the fact that if the monetary authorities in one country sterilizes the effects of the other country's monetary policy on its domestic money supply, the role of monetary policy in the other country is reduced to what it would be were the other country infinitesimally small.

In a two-country case (the United States and Europe) where all reserves are held in dollars, a US open-market operation changes the world money stock by more than an equal open-market operation in Europe. This is because reserve holdings of the European central bank are a source of the high-powered base of European money supply whereas these reserve holdings are low-powered money in the other part of the system, i.e. deposits with US commercial banks. A US expansionary monetary policy leads to an outflow of reserves that diminishes the US money stock by less than it raises the European money stock.

Moreover, European holdings of dollar reserves with the US commercial banking system automatically sterilize reserve flows. The reason for this is that - assuming domestic assets held by the US central bank as given - dollar holdings with US commercial banks reduce the reserves that are available to US commercial

banks for the backing of dollar balances held by US residents by the amount of dollar deposits of the European central bank with US commercial banks times the reserve ratio kept by US commercial banks. A deposition of the reserves with the Fed would instead have led to a fall in US commercial bank reserves equal to the European gain of foreign-exchange reserves. Swoboda (1978, p. 635) therefore concludes: "When Europe's central bank holds its reserves in U.S. Treasury Bills, a European payments surplus exerts no contractionary effect on the U.S. money supply. The money initially lost by the United States is put back into circulation when Europe buys U.S. Treasury Bills. Europe, in effect, performs open-market operations in the United States and neutralizes, as it were, on the Fed's behalf."

Swoboda's model stylizes the form of exchange-rate management in the Bretton Woods system. During the Bretton Woods era, the United States exerted 'benign neglect' with respect to its payments balances and thus to exchange-rate policy. It did not hold substantial currency reserves but borrowed foreign currencies through swap agreements when it chose to intervene for tactical reasons.<sup>3</sup>

More recently, US monetary authorities have accumulated significant foreign currency balances and more actively engaged in exchange-rate management. However, as US reserves are held partly by the Treasury and partly by the Federal Reserve, asymmetric monetary base effects can develop even with US intervention. When the Treasury sells Deutschmarks for dollars the US money supply does not change because the Treasury - more precisely, the Exchange Stabilization Fund where the Treasury holds its foreign-exchange reserves - use the dollars acquired through intervention to buy US government securities. Hence, the total stock of debt is not reduced - only the part held by the public is. By contrast,

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3. The swap agreements were basically used by the United States to buy back dollars from foreign central banks and by other countries to acquire dollars needed for intervention. Dollar holders could thus reduce exchange-rate risk.



the Federal Reserve withdraws the dollars acquired through intervention from the US money supply and the domestic effects of US intervention are thus not sterilized automatically [Kenen (1988, pp. 66 and 107)].<sup>4</sup>

### 3. Confidence and Convertibility Constraint in an International Monetary System

Central bankers expressed that "[the original impetus to diversification came from the collapse of the Bretton Woods system and the floating of exchange rates. This motivated many countries to try to maintain the real value of their assets or at least to increase the return on them" [Group of Thirty (1982, p. 4); emphasis in original]. This motivation has to be seen against the background that a reserve-currency country can finance payments deficits through the issuance of liabilities denominated in domestic currency and that it therefore has an incentive to inflate its currency in order to gain seigniorage by trading non-indexed nominal liabilities for real resources.<sup>5</sup>

In order to assure that a reserve-currency country provides a stable currency - and thus, a stable nominal anchor for the entire system - international monetary system created by agreement laid a convertibility constraint on the reserve currency. Under the classical gold standard each currency had a specific rate in terms of gold at which the issuing central bank had to exchange domestic banknotes for gold coins. This means that the value of Sterling - the international currency of the system - was stable as long as the production of gold did not exceed the pace of the growing

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4. The Bundesbank has tried to compensate short-term monetary-base effects caused by the international use of the Deutschmark by flexibly adjusting the amount offered in revolving repurchase agreements with commercial banks - so-called 'Wertpapierpensions-geschaeft' [see von Hagen (1989) for details on the Bundesbank's strategy].

5. 'Seigniorage gains' refer to the fact that absorption of a reserve-currency country can exceed its domestic production by an amount equal to the increase of other countries' holdings of its currency.

demand for reserves. Under the Bretton Woods system, a gold parity was defined only for the US dollar - the new international currency. The exchange rates of the other currencies were declared in terms of the US dollar. This means that under both the gold standard and the Bretton Woods system the value of foreign-exchange holdings was guaranteed as long as the gold convertibility of the international currency of the system was credible. The breakdown of the Bretton Woods system exposed dollar holders to significant devaluation risk because the convertibility of official dollar balances into gold was suspended and - with the adoption of widespread floating - exchange rate changes in the system could no longer be expected to typically involve depreciations of non-dollar currencies against the dollar. Hence, the only value-guarantee of dollar holders was their reliance on the pursuing of sound policies by US authorities - basically a predictable and low-inflationary monetary policy. Confidence in real-value stability of dollar assets therefore meant confidence in a predictable and low-inflationary monetary policy by U.S. authorities. This, however, could not be taken for granted.

### 3.1 Confidence and Reputation

Klein and Leffler (1981) show that the presence of a number of distinguishable currencies limits the ability of currency issuers to raise their seigniorage revenues by inflationary surprises. Their analysis is based on a situation where contracts between currency issuers and users are not enforceable by any third party and users thus rely solely on the threat to terminate the business relationship in order to enforce the contractual promises. Klein and Melvin (1982) assume that the building up and loss of reputation to issue a low-inflationary currency is a time-consuming process. This is comparable to a situation where there is no convertibility constraint of the reserve currency into a commodity and reserve holders rely on the threat to switch into another reserve currency in order to stimulate the reserve-currency country to follow sound economic policies. The reserve-currency country can, however, raise its seigniorage gains, i.e. consume its reputation,



for a certain period of time before reserve holders shift out of that currency.

By contrast, in a monopolistic market there is a short-run profit incentive to overissue because both the decrease in confidence of the overissued currency and the building up of confidence in potential alternatives are time-consuming processes. The considerable unanticipated increase in the dollar supply in the late 1960s and 1970s can thus - from the point of view of the United States - be interpreted as an optimal seigniorage policy in a monopolistic market but also as a basic reason for the development of the reserve system to a competitive market, i.e. a multi reserve-currency system.

Recovering the reputation of a currency issuer instead of instantly driving him out of business is important in the case of foreign-exchange reserves. The abrupt shift of reserve holdings from one currency into another would have enormous repercussions on exchange rates. Foreign-exchange holders may therefore respond to the loss of reputation of the issuer of a reserve currency by only partially moving out of that currency, provided that the currency issuer credibly precommits himself to a value-stabilizing monetary policy.

A currency issuer may recover reputation by credibly precommitting to a value-stabilizing monetary policy. Recent economic theory - following Kydland and Prescott (1977) and Barro and Gordon (1983a,b) - has made clear that the condition for this is time-consistency of the policy rules announced by the currency issuer. A policy is time-consistent if it is known by economic agents to be optimal with respect to the policymaker's objective function for the entire future path of the economy. Since in an economy with infinite time horizon, the policymaker always has an incentive to surprise inflation, his incentive for raising seigniorage gains by overissuing in the present must be lower than his perceived loss of discounted future seigniorage gains. The expected costs of surprise inflation to the policymaker depend on the ready availability of securities denominated in alternative currencies and on the policymaker's perceived loss of control over

monetary policy caused by turmoils in the domestic capital market after shifts out of his currency.

In a rational-expectations model, Calvo (1978) shows that the time-consistent solution to the optimal seigniorage problem of maximizing the discounted (by the constant rate of return of capital) sum of the present and future streams of seigniorage is a constant rate of growth of currency issuance - equaling a perfectly predictable growth rate. This implies that if the objective of the reserve-currency country is to maximize the discounted sum of seigniorage at every point in time, no time-consistent optimal solution can be achieved. This is because an optimal solution would imply changing rates of the currency supply, i.e. a revision of the currency issuer's policy over the course of time. The promise of monetary authorities not to overissue is therefore not credible.

Currency holders may thus adopt a form of control rule by which the policymaker loses reputation if the observed inflation rate exceeds some critical value. This means that a given inflation rate does not in all cases cause a punishment because currency holders may attribute part of their value loss to exchange risk for which the policymaker is perceived as not responsible. On the other hand, a relatively low rate of inflation may lead to punishment if currency holders perceive that this source of depreciation was intentionally reinforced by the policymaker via a depreciation of the currency in question. In other words, because of the uncontrollable element exchange risk, a loss of reputation - and hence, a punishment - occurs from time to time and at different rates of inflation [see also Barro and Gordon (1983b, p. 119)].

To summarize, if time-consistency of the optimal solution to seigniorage policy is to be recovered, constraints on the policy variables of the currency issuer have to be introduced. Currency issuers know that - in the long run - they can do better than the short-sighted solution. By acting consistently over long periods they hope to build up a reputation which leads asset holders to believe their announcements. This argument will be modeled in the following section.



### 3.2 The Model

The objective of the model is to illustrate the stabilizing impact of the presence of a number of reserve currencies on the real value of official currency reserves. The model is based on the view that the fact that reserve holders diversify the currency composition of their portfolios represents a new form of convertibility constraint on reserve-currency countries, i.e. that it provides an incentive for these countries to follow low-inflationary monetary policies.

As the reserve-currency country has an incentive for running an inflationary monetary policy and for thereby reducing the real value of non-indexed nominal securities denominated in its currency, rational asset holders discount potential value losses. If foreign-exchange holders perceive that the reserve-currency country deliberately depreciates their holdings, they either ask for a higher return on their assets or switch into another - more stable - currency. This means that the reserve-currency country cannot run an inflationary monetary policy without cost. It would either have to pay higher interest on assets denominated in its currency or have to face diversification out of its currency, i.e. incur a loss of discounted future seigniorage revenues.

The scenario described would not become true if monetary authorities could credibly precommit themselves to a non-inflationary policy. The monetary authorities can compensate their lack of reputation by effectively delegating monetary policy to a more credible monetary authority, i.e. 'tying their hands' by cooperating with a central bank of higher reputation. This is similar to Rogoff's (1985) parable of surrendering one's monetary policy to a 'conservative' central banker.

The basic ideas of the model draw on the literature following Barro and Gordon (1983a,b) and Rogoff (1985). This literature focuses on the expectational Phillips curve and looks at welfare gains in terms of less inflation in a domestic macroeconomic policy setting. The authorities' objective function includes output and inflation and the central bank credibly precommits itself to a

low-inflationary monetary policy by appointing a conservative central banker. This approach was applied to the European Monetary System by Giavazzi and Pagano (1988) who study the advantage an inflation-prone country gains by surrendering independence of its monetary policy in exchange for the Bundesbank's reputation. In this study, a similar approach is taken to analyze the impact of diversification of foreign exchange holdings of central banks on the monetary policy stance of countries issuing a reserve currency.

The model focuses on the impact of the presence of more than one reserve currency on the monetary policy of a reserve-currency country. The reserve-currency country is assumed to have a kind of exogenously set lower target level,  $\bar{q}$ , with regard to the share of its currency in total official foreign-exchange holdings. The reserve-currency country may set this target level according to the country's importance in international transactions, i.e. to the use of its currency as a vehicle [see also Deutsche Bundesbank (1984, p. 13)]. The core of this assumption is similar to Posthuma's (1963a,b) suggestion that reserve holders should diversify their portfolios according to a specified rule. However, while Posthuma proposed applying the rule to portfolios of individual countries, the assumption made here regards a target rule applied by the reserve-currency country with respect to total foreign-exchange holdings. That is, focus is on the stock of outstanding assets denominated in the specific reserve currency while flows of reserve assets between holders are not taken into account. This is because only changes in the stock of holdings influence the seigniorage revenues of the reserve-currency country.

Starting from a given initial share  $q(0)=q_0$ , it is further assumed that a decrease of the currency's share below  $\bar{q}$  imposes constraints upon the monetary authorities. More specifically, after an exogenously determined length of time of  $T$  periods, the policymaker changes monetary policy so as to set the share of his currency in official foreign-exchange holdings at time  $t$ ,  $q(t)$ , somewhere above his target level  $\bar{q}$ . That is  $q(T) > \bar{q}$ . This change in policy stance is coupled with the policymaker's adoption of a



credible precommitment to low-inflationary policy, i.e. foreign-exchange holders do not expect any real value losses after this change.

Deviations of  $q(t)$  from  $\bar{q}$  are assumed as determined by a function of the cumulated inflation differential between the policymaker's currency and an alternative reserve currency, where  $\pi(t)$  denotes the inflation differential. Changes in the real exchange rate between two reserve currencies may also be a source of reserve switching, meaning that deviations of  $q(t)$  from  $\bar{q}$  would also be a function of the cumulated real depreciation,  $w(t)$ , of the policymaker's currency with respect to an alternative reserve currency. Hence, depreciation of outstanding reserve assets denominated in a specific currency due to inflation may be compensated by an appreciation of the inflationary currency. On the other hand, if an inflationary currency experiences exchange-rate depreciation at the same time, diversification might exceed the level suggested by the inflation rate alone. The dollar between 1982-1985 may be an example of the former case while the dollar between 1978-1980 may be an example of the latter.

However, as Swoboda (1988, p. 100) notes, under flexible exchange rates both nominal and real exchange rates are endogenous variables. In addition, as there is no generally accepted exchange rate model the impact of inflation on the development of exchange rates cannot be fully explained. Consequently, the exchange rate cannot be regarded as a control variable of the policymaker and is thus considered as exogenous in the model. The consideration that a depreciation of reserve holdings due to inflation does not in all cases lead to the same extent of diversification is taken into account by a scale variable,  $b$ , which reflects the extent to which real value losses are perceived by currency holders as deliberately caused by the currency issuer.

A further assumption is that the path of central bank diversification - and, thus  $q(t)$  - is independent of the level of a specific central bank's holdings of that currency. In other words, a central bank with substantial holdings of a specific currency does not diversify faster than a central bank with lower holdings

of this currency if the real value of assets denominated in that currency depreciates. This assumption appears reasonable as substantial reserve switching can reinforce exchange-rate variability and holders of considerable foreign-exchange balances can therefore be assumed to have a 'stability concern', i.e. to refrain from substantial switching between reserve currencies. The path of  $q(t)$  is thus given by

$$(1) \quad q(t) = q_0 - b \int_0^t \pi(s) ds$$

with:  $q(0) = q_0$       and       $q(T) > \bar{q}$

The authorities have an incentive for creating surprise inflation ( $\pi(t) - \pi^e(t)$ ) so as to raise their seigniorage gains in the short run. However, the authorities dislike price instability - captured by a term quadratic in inflation,  $\pi^2(t)$  - due to the cost of anticipated inflation, in particular the potential rise of endogenous relative price uncertainty.

The cost of surprise inflation to the authorities is captured by two variables. Since the temptation to overissue, i.e. raising present seigniorage gains, is balanced by the perceived loss of discounted future seigniorage revenues caused by holders' shifting out of the inflationary currency, the discount factor applied by the authorities is crucial. This feature is represented by  $\rho$  which reflects the authorities' rate of time preferences.

On the other hand, asset holders may ask for a higher interest payment at the time they want to renew investment in assets denominated in the inflationary currency so as not to diversify. Two main assumptions are added. Domestic interest rates are assumed to be linked to interest rates in the international financial market through uncovered interest rate parity. In addition, the monetary authorities are assumed to put a negative weight on the variability  $v(t)$  of the path of nominal interest they have to pay on outstanding assets  $i(t)$ . The variability of the path of nominal interest payments depends on the deviation of the interest paid on a security issued at time  $t$  maturing at time  $t+\tau$  from a target lev-



el,  $\bar{w}$ . The target level indicates the interest payment on a security with maturity  $\tau$  in the international financial market.

There are good reasons for monetary authorities to worry about the variability of nominal interest payments on outstanding assets. For example, in countries which have a substantial amount of outstanding liabilities, the variability of interest payment on government securities induces considerable fluctuations in government expenditure, and these, presumably, are undesirable. In addition, the variability of nominal interest payment to asset holders abroad causes fluctuations in short-term capital exports which may reinforce short-term instability of nominal exchange rates. Moreover, changing deviations of the return a country has to pay on assets denominated in its currency from the level given in the international financial market can cause endogenous uncertainty about the country's creditworthiness.

It is further assumed for convenience that assets are issued continuously<sup>6</sup> and that the nominal interest rate is adjusted continuously according to the accumulated inflation differential between two alternative reserve currencies in order to compensate asset holders for the capital loss incurred at the time they want to renew their investment in the inflationary currency. The specific maturity of the asset,  $\tau$ , is a parameter of the problem because it determines the time structure of the rise in interest payments. As in each period only  $1/\tau$  assets are to be re-invested, the level to which a given rise in inflation constitutes a rise in seigniorage gains depends inversely on  $\tau$ .

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6. Note that the assumption of a continuous stream of asset issuing holds strictly true only if the secondary market for assets is included. Monetary authorities themselves issue assets at discrete time intervals. However, the inclusion of discrete time problems would unnecessarily complicate the model without changing its basic results [see Giavazzi and Pagano (1988) for a similar model dealing with discrete time problems].

With  $T < \tau$ , the deviation of the authorities' nominal interest payments on outstanding assets from their target level can accordingly be written as

$$(2) \quad v(t) = \frac{1}{\tau} \int_0^t \pi(s) ds - \bar{w} \quad \tau > 0 \quad \bar{w} > 0$$

This yields the following expression for the policymaker's objective function:

$$V = \int_0^T e^{-\rho t} [h q(t) + c(\pi(t) - \pi^e(t)) - (a/2)\pi^2(t) - (f/2)v^2(t)] dt$$

$$h, c, a, f > 0$$

subject to  $q'(t) = -b\pi(t)$

with the boundary conditions  $q(0) = q_0$  and  $q(T) > \bar{q}$

and  $v'(t) = \frac{1}{\tau}\pi(t)$

with the boundary conditions  $v(0) = v_0$  and  $v(T)$  free.

Note that it is also implicitly assumed that the interest rate elasticity of money demand is zero, and that output demand does not respond to fluctuations in interest rates. These assumptions seem reasonable as the fluctuations of interest payments considered are short-run phenomena, concentrated around the date of the authorities' change in the stance of monetary policy.

The policy-maker's problem is to maximize  $V$ . His control variable is the rate of money creation, i.e. the rate of inflation  $\pi(t)$ ; the solution is an optimal rule for  $\pi(t)$ , to be denoted  $\pi^*(t)$ . For this rule to be time-consistent, the policy-maker must regard expected inflation  $\pi^e(t)$  to be independent of its own actions, treating it as exogenous in the maximization problem [see Barro and Gordon (1983a, pp. 595-596) and Giavazzi and Pagano (1988, p. 1059)]. This is because under rational expectations, equilibrium is reached at  $\pi^e(t) = \pi(t)$  and surprise inflation does not raise the policymaker's seigniorage gains. The policymaker's temptation for creating surprise inflation is merely a source of inefficiency, and precisely this inefficiency is supposed to be



corrected by the 'new' convertibility constraint. Thus, in the maximization problem, the term  $(\pi(t) - \pi^e(t))$  does not change over the course of time.

The Hamiltonian is:

$$H(\pi, q, \lambda, \Psi) = hq + c(\pi - \pi^e) - \frac{a}{2}\pi^2 - (f/2)v^2 + \lambda(-b\pi) + \Psi\left(\frac{1}{\tau}\pi\right)$$

$$\text{Accordingly, } \frac{\partial H}{\partial \pi} = c - a\pi - b\lambda + \frac{1}{\tau}\Psi$$

$$\text{The first order condition yields } \pi(t) = \frac{1}{a} [c - b\lambda(t) + \frac{1}{\tau}\Psi]$$

$$\text{Then: } \lambda'(t) = \rho\lambda - \frac{\partial H}{\partial q} = \rho\lambda - h \qquad \lambda(T) = 0$$

$$\lambda(t) = \frac{h}{\rho} (1 - e^{-\rho(T-t)})$$

and, assuming the interest rate on a security of maturity  $\tau$  - and thus  $\bar{w}$  - in international financial markets as equal to zero,

$$\Psi'(t) = \rho\Psi - \frac{\partial H}{\partial v} = \rho\Psi + f^2v \qquad \Psi(T) = 0$$

$$\begin{aligned} \Psi(t) &= -\frac{f^2}{\rho} (1 - e^{-\rho(T-t)}) \int_0^T v(t) dt \\ &= -\frac{f^2}{\rho} (1 - e^{-\rho(T-t)}) \left( \frac{1}{\tau} \int_0^t \int_0^u \pi(u) du dt \right) \end{aligned}$$

Accordingly, the optimal path of inflation satisfies:

$$\pi^*(t) = \frac{1}{a} [c - \frac{bh}{\rho} (1 - e^{-\rho(T-t)}) - \frac{f^2}{\tau\rho} (1 - e^{-\rho(T-t)}) \left( \int_0^T \int_0^t \pi(u) du dt \right)]$$

$t$  of  $[0, T]$

This result suggests that optimal inflation increases monotonically until the date of the policymaker's change in policy stance. The reason for the continuous rise of optimal inflation is that it is best to concentrate inflation at the end of the interval so as to carry the implied loss of seigniorage gains over a

shorter period. The slope of the rise in inflation is steeper the smaller the policymaker's discount factor  $\rho$  regarding his perceived loss of future seigniorage revenues. If the policymaker does not have to fear shifts out of his currency, e.g. because there are no readily available alternatives, he gives in to the temptation to overissue. The slope of inflation approaches a constant as  $\rho \rightarrow \infty$  which represents the case in which the currency issuer gives less and less weight to the impact of current inflation on the future level of seigniorage gains. The rate of optimal inflation is also increasing in  $\tau$ , the maturity of reserve assets, since the longer the maturity is, the longer is the period of time for which the authorities do not have to compensate asset holders for value losses.

On the other hand, the rate of optimal inflation is decreasing in  $T$ , the length of the time interval before the change in policy stance. This is because the longer the policymaker manages to postpone the change of policy stance, the longer is the period of time for which a given increase in inflation remains embodied in the path of diversification.

The role of the other parameters is also in accordance with intuition: the rate of inflation is increasing in  $c$  (the incentive to produce surprise inflation) whereas it is decreasing in  $h$  (the marginal value of a diversification), in  $a$  (the marginal cost of price instability), in  $b$  (the extent to which foreign-exchange holders perceive real value losses as deliberately caused by the currency issuer), and in  $f$  (the marginal value of the variability of nominal interest payments).

To derive the rate of inflation in the case when the reserve-currency country does not have an interest in keeping the share of its currency in reserve holdings at a certain level, i.e. if the convertibility constraint is absent,  $q(t)$  is assumed exogenous. This gives the constant inflation rate

$$\pi^*(t) = c/a$$

for the path of inflation excluding the interest-rate variable.



Comparing  $\pi^*(t)$  and  $\tilde{\pi}^*(t)$  shows that the average inflation rate is smaller when the reserve-currency country is subject to the convertibility constraint. This witnesses the effectiveness of the discipline imposed by diversification of foreign-exchange holdings.

The workings of the 'new' convertibility constraint may be exemplified by the dramatic change in the US economic policy stance in 1978 and 1979. By that time, the overall US inflation rate, as measured by the GDP deflator, had risen from a post-recession low of 6.3 percent in 1976 to 8.8 percent in 1979. The comparable rise measured by consumer prices was from 5.8 percent to 11.3 percent, the highest rate since 1946. At the same time dollar exchange rates declined between 1976 and 1979 by 16.8 percent on a trade-weighted basis. Especially once the OPEC announced another major hike in crude petroleum prices, fears of an uncontrollable inflation spiral or a precipitous decline in the dollar, or both, began to spread.

As it had become obvious that the dollar was not a reliable stable currency any longer investors attempted to avoid value losses by shifting from dollar assets into other currencies or gold holdings. US authorities reacted by announcing a far-reaching rescue program for the dollar on November 1, 1978. Apart from rise of the discount rate, the program included a \$ 30 billion package of foreign-currency financed US participation in coordinated intervention in the exchange markets. The new approach taken in this respect was the issuing of \$ 10 billion foreign currency-denominated securities (so-called 'Carter bonds') and the building-up of substantial foreign-exchange reserves (from 27 to 2,911 millions SDRs between October and November 1978). The adopted measures were, however, only temporarily successful and thus - on October 6, 1979 - the Fed raised the discount rate and announced that it would focus on the supply of bank reserves rather than guide the federal funds rate in order to achieve the targets for the various monetary aggregates.

As Fed Chairman Volcker pointed out: "Above all, the new measures should make abundantly clear our unwillingness to finance a

continuing inflationary process" and "[i]nflation feeds in part itself, so part of the job of returning to a more stable and more protective economy must be to break the grip of inflationary expectations" [Federal Reserve Bulletin (1979, pp. 888-889)].

This means that the events in 1978 and 1979 brought about a change in the US attitude regarding the reserve role of the dollar and the engagement of US authorities in exchange-rate management. US authorities adopted a more monetarist monetary policy by controlling bank reserves rather than interest rates. This was perceived by exchange markets as the Fed members' acting as 'hard-money guys'. To make the shift in the monetary stance credible, the Fed dramatically raised its foreign-exchange reserves at the end of 1978 in order to actively engage in coordinated exchange-rate management with the other major industrial countries. This can be interpreted as the US authorities' attempt to import reputation from other central banks, in particular from the Bundesbank, by participating in a close management of the DM-dollar exchange rate and adopting a tight monetary policy following the path set by the Bundesbank.

#### 4. Conclusions

The foregoing discussion suggests the following conclusions. The still dominant role of the US dollar as reserve currency can be explained by three aspects. Firstly, the United States still has the largest domestic economy in the world, evidenced by a comparison of gross domestic products (GDP) of the United States, Germany and Japan. According to the 'relative size criterion', the US dollar should therefore be the  $n$ -th currency in the international monetary system. Secondly, the US dollar is the main vehicle currency in the world economy and both private economic agents and central banks therefore minimize transactions costs by holding and using dollars. Thirdly, the US capital market is characterized by a relative advantage in breadth, depth and resiliency over German and Japanese markets. This means, for example, that the supply of short-term Treasury securities, in which central banks tend to invest a substantial part of currency reserves, is



much bigger for dollar-denominated than for DM-denominated assets. The risk of dollar investors is therefore relatively low. Moreover, the relatively thin and less resilient German capital market has made the Bundesbank reluctant to promote a more extended reserve role for the Deutschmark. This position is motivated by a perceived loss of control over monetary aggregates caused by substantial shifts in and out of the Deutschmark.

On the other hand, the Deutschmark seems to have obtained its reserve-currency role thanks to the Bundesbank's reputation of providing a stable and predictable currency. Such reliability motivated central banks to diversify their currency portfolios in order to reduce the risk of real value losses. In addition, it led US authorities to more actively engage in managing the DM-dollar exchange rate, i.e. including an exchange-rate target in their objective function in order to credibly precommit US monetary policy by following the low-inflationary path set by the Bundesbank. US authorities thus import the Bundesbank's reputation in order to reestablish their own reputation lost through above-average inflation between the late-1960s and late 1970s.

It has to be stressed, however, that setting the DM-dollar exchange rate as policy objective and import reputation from the Bundesbank is only needed when dollar holders incur real value losses. The probability of such losses is relatively low in periods of a strong dollar - differences in inflation rates between reserve currencies would have to overcompensate value changes caused by exchange-rate changes - and there is thus no immediate incentive for dollar holders to diversify during those periods.

Against this background, the substantial move out of the dollar by central banks of industrial countries in 1978 and 1979 - a period when the dollar was weak and reserve diversification therefore reinforced exchange-rate variability - can be regarded as a signal from the major dollar holders to the United States that they will not accept any further depreciation of their holdings. US authorities responded to this signal by drastically changing their monetary policy stance, reinforcing the credibility of this

change by adopting a target with respect to the DM-dollar exchange rate and actively engaging in exchange-rate management. At the same time, Germany and Japan experienced considerable current-account deficits and came to appreciate the reserve role of their currencies because they found it advantageous to balance payments deficits by issuing liabilities denominated in domestic currency.

On the other hand, the second period of substantial reserve diversification by industrial countries - between 1981 and 1986 - took place despite the sharp appreciation of the dollar against the other reserve currencies. This may indicate that dollar holders used substantial amounts of their reserves for interventions to influence the dollar exchange rate. However, it may also indicate that dollar holders took advantage of the dollar appreciation to change the currency composition of their reserves without risking an aggravation of exchange-rate variability. The ongoing considerable level of diversification out of dollar into Deutschmark and yen holdings despite the fact that the dollar exchange rate has been relatively stable since 1986 lends supports to the latter proposition.

The basic dualism in the present reserve system between the US dollar and the Deutschmark can be interpreted as having reestablished the convertibility constraint on reserve-currency countries lost by the removal of gold convertibility of official dollar balances. The constraint on US authorities consists in the ready availability of the Deutschmark as reserve asset in case of their deliberate depreciation of dollar holdings. The constraint on German authorities consists in the potential dramatic repercussions on the German capital market. This is because an inflationary policy of the Bundesbank tends to cause considerable shifts out of DM-markets.

However, the new convertibility constraint is based on this feed-back mechanism and thus on sound economic policies in at least one of the two countries. But due to the close integration of international capital markets, other currencies would always be easily available alternatives should German and US authorities jointly depreciate Deutschmark and dollar holdings by coordinated



inflationary policies. Currency diversification of central banks' reserve portfolios can therefore be regarded as a stabilizing element in the international monetary system.

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